Irrigation as a Low Cost Method of Sewage Disposal for the Poultry Processor

Agricultural Marketing Service
Marketing Research Division
Washington, D.C.
Marketing Research Report No. 306

U.S. Department of Agriculture

PREFACE

This report is the last of three publications dealing with poultry byproducts and wastes. The first, Utilization and Disposal of Poultry Byproducts and Wastes, Marketing Research Report No. 143, issued November 1956, described the nature and volume of byproducts and wastes and set forth the need for further research. The second, Processing Poultry Byproducts in Poultry Slaughtering Plants, Marketing Research Report No. 181, issued June 1957, presented the results of a technical and economic study of poultry waste rendering processes. This report provides information regarding the disposal of waste water from poultry processing.

The information and recommendations presented in the following report are based on a study made under a research contract with the U. S. Department of Agriculture by the Midwest Research Institute. The report is part of a broad program of research designed to increase the efficiency of the marketing processes for farm products.

The Western Utilization Research and Development Division, Agricultural Research Service, cooperated in supervising the technical portions of the study and designated J. G. Davis, of Albany, Calif., to supervise the chemical and engineering aspects of the research under the contract. Mr. Davis assisted in preparing and reviewing this publication.

March 1959

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 15 cents

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Irrigation as a low cost method of sewage disposal for the poultry processor [by Frank M. Ross and Humbert Scott Kahle] Washington [U. S. Govt. Print. Off., 1959]

24 p. illus. 27 cm. (U. S. Dept. of Agriculture. Marketing research report no. 306)

Bibliography: p. 22–23.

1. Poultry plants[—Sanitation] 2. Sewage irrigation. I. Kahle, Humbert Scott, joint author. (Series)

HD1751.A9183 no. 306 628.3 Agr 59–65

U. S. Dept. of Agr. Libr. 1Ag84Mr no. 306
for Library of Congress †

SUMMARY

Increasing demands on sewage disposal systems, together with public concern over stream pollution, point to the need for an alternative means of disposal for this liquid waste. Many well managed plants in food processing industries have discovered that their effluent can be converted to irrigation water through simple treatment and some modification in handling methods. The effluent can then be disposed of through standard irrigation practices and be absorbed by the soil and the cover crop without constituting a health nuisance or being otherwise objectionable.

The sprinkler and the ridge and furrow irrigation systems are suitable for the disposal of effluent. Ridge and furrow systems require a large volume of effluent, whereas sprinkler systems can be utilized by either large or small plants. Of the two, sprinkler or spray irrigation is the more widely accepted. A sprinkler system is readily adapted to different rates of soil absorption, irregular topography, excessive slopes, and erosive soils, and appears to satisfy most of the requirements for sewage disposal in poultry slaughtering plants.

For most plants the total investment for a sprinkler irrigation system can be kept below $25 per thousand pounds of weekly slaughter. For plants slaughtering less than 50,000 pounds per week, the figure might run as high as $50 per thousand pounds, but it can be reduced to less than $20 for the larger plants. The annual costs for all except the very smallest plants should not exceed $10 to $20 per thousand pounds of weekly capacity.

A sprinkler irrigation system can be relatively inexpensive. Moreover, it can help pay for itself through increased crop yields, and the equipment used has considerable salvage value.

IRRIGATION AS A LOW COST METHOD OF SEWAGE DISPOSAL FOR THE POULTRY PROCESSOR

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INTRODUCTION AND OBJECTIVES

As of January 1, 1959, all poultry and poultry products moving in interstate or foreign commerce became subject to inspection for wholesomeness by representatives of the U. S. Department of Agriculture. Effective sewage disposal will be one of the minimum operating requirements for poultry processing plants.

Sewage 2/ from large poultry slaughtering plants can exceed 100,000 gallons per day. When such large quantities of waste water are discharged into municipal sewage systems or waterways without treatment, additional operating and maintenance costs are transferred to the general public, and the added waste water may overburden disposal facilities. The disposal of sewage is regulated in many areas by local and State ordinances. Some of these ordinances establish stringent controls over pollution of public sewers and waterways. Other States and communities may take similar steps in the future. It may be, therefore, in the plant operator's interest to be prepared to provide his own sewage disposal facilities.

Sewage can be disposed of through any one of several installations. In some instances, city sewers, the preferred method of disposal, are available. In other areas, conventional methods of sewage treatment, such as trickling filters or activated sludge, may be available or may be required. For many processors, however, these facilities may not be available or they may not have the capacity to handle poultry sewage. These processors may be in a position to consider a number of alternatives, including irrigation, as a means of disposal. For such processors, we present the following report in the hope that it may help in choosing the alternative which may be most desirable.

1/ Mr. Ross was in charge of the study for the Midwest Research Institute. Mr. Kahle supervised the contract for the Department of Agriculture.

2/ "Sewage," as used in this study, refers to the liquid waste from poultry slaughtering plants and is the screened water resulting from all operations which are performed in processing poultry, including receiving, killing, picking, eviscerating, chilling, packing, and cleaning. It does not include the domestic sewage from washrooms and toilets used by plant personnel.

The report will not give all of the information required for designing a plant. On the contrary, this type of work should be left to a professional engineer.

It is also essential that the poultry processor communicate with State and local health officials to insure compliance with applicable laws and regulations. Plants engaging in interstate commerce must communicate with a representative of the Inspection Branch, Poultry Division, Agricultural Marketing Service, U. S. Department of Agriculture, before starting installation. According to the Inspection Branch, sewage may be discharged into a municipal sewer system and if this is permitted by local ordinance it is most desirable. If the discharge is into a stream, the flow of water in the stream should be sufficient at all seasons of the year to carry the sewage well away from the plant. This report suggests consideration of spray irrigation. It is recommended that any proposed irrigation system be checked by local or State health authorities having jurisdiction over such matters to determine if it is acceptable.

A letter from the proper health authority (State, county, city) indicating that the proposed sewage system is acceptable should be submitted to the Washington office before installation of the irrigation equipment.

Six basic considerations determine the advisability of a poultry slaughtering plant's using an irrigation system:

(1) Method of removing blood and solids must be simple and inexpensive.

(2) The area to be irrigated should be remote from heavily populated areas and public water sources.

(3) The ability of the soil to absorb and dissipate water must be commensurate with the volume discharged from the plant.

(4) Climatic conditions must be compensated for to the extent that they affect the saturation point of the soil (i. e., heavy rainfall, days of freezing weather, etc.).

(5) The cover crop must be adaptable to the region and should have high water-consuming properties.

(6) The irrigation system must be consistent with the locality, the climate, and the topography.

A previous study showed that a trickling filter sewage disposal system for a plant discharging 100,000 gallons per day required an investment in excess of $60,000 and annual operating costs of over $18,000 (4). 3/ On the

3/ Underscored figures in parentheses refer to items in Bibliography, p. 22.

other hand, this same study estimated the investment cost of an irrigation system discharging 100,000 gallons per day at $22,000 and the annual operating cost at $6,310.

Irrigation systems for industrial waste disposal have proved economical and practical. A growing number of canneries and dairies are disposing of liquid wastes in this manner. This report discusses irrigation systems for waste disposal in poultry slaughtering plants. The study was designed:

(1) To consider the feasibility of using irrigation systems for the disposal of waste water from poultry slaughtering plants.

(2) To ascertain and report the benefits which may be realized from such installations.

(3) To present typical data which could be used for estimating investment and operating costs.

The report also discusses the secondary effects on investment, operating costs, and benefits of such factors as chemical and physical characteristics of the waste, cover crops, acreage and type of land, climatic conditions, and other pertinent factors.

IRRIGATION SYSTEMS FOR WASTE DISPOSAL

Beginning about 10 years ago, the disposal of liquid industrial waste through irrigation systems was initiated by several food processing industries.

In May 1957, 48 of the 126 canning factories listed by the Wisconsin Canners Association were using irrigation systems for waste water disposal. Similar growth in acceptance of this method of disposal has taken place in some other States. Dairies and cheese factories also are using irrigation systems. 4/

The deterrents to a more universal adoption of an irrigation system for poultry slaughtering have been:

(1) Poor engineering and soil selection, which have resulted in excessive costs and inefficient waste disposal.

(2) Careless operations and housekeeping practices, which have resulted in public health nuisances.

(3) Failure to provide adequately for special conditions such as climate and locality.

4/ Unpublished data of the Committee on Water Pollution, State of Wisconsin, relative to volume of waste output, acreage, and type of soil at Wisconsin cheese plants. May 1, 1957.

A review of the published data regarding the chemical analyses of cannery, dairy, and poultry slaughtering waste indicates that poultry slaughtering wastes, excluding effluent from battery feeding, average 300-1,500 BOD (biochemical oxygen demand), and that cannery and dairy wastes average 800-3,000 BOD. Many dairies and canneries are disposing of waste water through irrigation systems, and it seems safe to assume that manure-free sewage from poultry slaughtering plants can be handled in a similar way. Many of the smaller poultry processing plants are located in rural areas near centers of production, where land for sewage disposal is available.

Regulations and customs governing most poultry slaughtering usually require that all manure, debris, inedible byproducts, and blood be collected separately, removed from the processing area, and disposed of daily. If these practices are strictly observed, and if sufficient water is used (table 1, page 12), the pollutionary elements of the waste water should not prevent its use for irrigation purposes. This water is polluted, however, and it is important that the entire irrigation system be designed so that the effluent will be absorbed into the soil with minimum delay.

Ridge and Furrow and Sprinkler Irrigation Systems

Of the several different methods used in irrigation, two types, ridge and furrow systems and sprinkler or spray systems, seem useful for the disposal of poultry processing waste. Sprinkler irrigation, having had a more general acceptance by canners and dairies, is emphasized in this report.

Sprinkler systems have been accepted because they are more adaptable to any land contour. Ridge and furrow systems require that the land be almost flat or well graded; not over 7 percent grade is recommended, and the grade must be uniform to prevent puddling.

Ridge and furrow irrigation is especially useful in northern climates because the cover crop protects the furrows from snow and permits the waste water to flow through the fields during freezing weather. This avoids the serious winter killing of the cover crop due to ice formation, which is sometimes associated with sprinkler systems.

Because solids which escape the screening and desilting basins collect in the furrows, ridge and furrow systems are more subject to odors and insect infestation than sprinkler systems are.

Ridge and furrow systems have the advantage of reduced requirements for power and equipment, provided a suitable field is available. Distribution boxes to assure equal delivery constitute the major equipment requirement. Open furrows complete the system. On fields with more than a 7-percent grade, the furrows may be run diagonally across the slope to minimize the grade and to prevent excessive velocities. Length of the furrows will depend upon the soil absorption rates and the cover crop.

A sprinkling system uses rotating sprinkler heads mounted on pipes which may either be portable or be permanently installed. Less equipment investment is required for a portable system because the laterals and the sprinkler heads may be moved to different locations as needed. Portable pipes may also be preferred because they have a greater resale value than used permanent pipes.

The installation of a permanent system is more expensive than that of the portable one, but the permanent system is very economical to operate because the sprinkler heads are turned off and on by valves and no labor is needed to move pipes to new locations. In addition, the buried pipes do not obstruct harvesting equipment or grazing animals. A permanent system is, of course, limited to the exact area contemplated in the original layout. Moves to new areas are expensive and time consuming.

Cover Crops and Crop Benefits

Suitable cover crops are essential for the proper operation of a spray irrigation system. The evaporative effects of the cover crop, plus the soil conditioning effects of the root systems, can be more important than soil capacity or permeability. The cover crop should receive careful attention throughout the year. Hay crops, including grasses and legumes, protect the soil against impaction from the falling water, prevent erosion, and evaporate large quantities of water into the air through their leaves. For proper utilization of cover crops, moisture-free periods must be available for harvesting or pasturing, and rotational sprinkling must be provided to prevent water damage to roots.

Studies of the benefits of irrigation show increases in crop production which range from 50 percent in humid areas to 100 percent or more in dry areas. This assumes proper water management. Improper water management, such as flooding or soil saturation, may actually reduce yields. The use of irrigation systems for the disposal of industrial wastes, however, involves different considerations than the usual crop irrigation system.

(1) Crop irrigation starts with a known acreage, and water requirements must be computed. With waste disposal the volume of water is generally known, and acreage is dictated by water intake, retention, and transmission.

(2) Crop irrigation calls for a minimum application of water. Waste disposal is concerned with the maximum practicable application and the dissipation of water through transpiration from the cover crop.

(3) With crop irrigation, water application is adjusted to crop requirements. With waste disposal, the choice of the crop may depend on the desired rate of application of water.

(4) Water used for crop irrigation is seldom polluted. This is not usually the case with waste disposal.

(5) Crop irrigation is required intermittently to supplement natural rainfall. Waste disposal continues in uniform volume--rain or shine, hot or cold.

Determining Land Area Required

In his article in the June 1954 issue of Municipal Utilities (7), H. W. Powell says, in part, "One problem is the proper selection of land and the crop for irrigation. The area of the land will vary with its nature and the quantity of liquid to be disposed of. Local land surveys can be of assistance in land selection. Even boring of the soil is resorted to in some instances."

Considerations which have a direct bearing on the determination of required acreages are:

(1) Soil texture: Sandy soils will generally permit free movement of water; finer soils will hold more water, but they do not permit rapid and continued penetration.

(2) Depth of the soil: Shallow soils interrupt the free dissipation of the water applied.

(3) Underground channels: If these channels are near the surface, they may carry the water to underground water supplies before purification of the water is complete.

(4) Natural moisture content of the land: Some bottom land soils are habitually saturated and therefore are unsuited to waste disposal.

(5) Availability of ponds or lagoons: These can be used to store excess water caused by unusual increases in volume of effluent, sudden thaws after winter irrigation, applications after heavy rains, etc.

Many effective installations of irrigation systems for waste disposal from canneries and milk processors were observed, and others have been described in published reports. Typical requirements for various types of land and different volumes of effluent are presented in the appendix.

Each installation is a separate problem (12). In spite of the fact that definite criteria are not available, county agents, soil conservation agencies, etc., can be of assistance to a plant operator in determining the characteristics of the soil and in pointing out characteristics which would definitely limit the volume of effluent which might be applied. However, because such estimates are seldom accurate, it is advisable to reserve additional land in case the first estimate proves to be low. If possible, an operator should provide for an experimental installation before making a permanent installation.

It should be possible to borrow or rent irrigation equipment for use during the fall and winter seasons and thus test the adaptability of the soil. The small quantities of runoff during the experimental stages of acreage determination will cause no serious difficulties.

It is desirable to have a large enough acreage so that the soil can be given time to dry sufficiently to permit the penetration of oxygen and nitrogen to the roots of the cover crop and of oxygen to the soil bacteria. Otherwise, the ground may become waterlogged, and the effectiveness of the soil bacteria in removing pollution will be greatly reduced.

Effects of Special Climatic Conditions

Heavy slaughtering of poultry often takes place during the winter when plants in northern States face protracted periods of freezing weather. Water discharged on the fields by spray irrigation in freezing weather may form an icecap upon the field. The cover crop will also be dormant and have little or no effect upon disposing of the water which reaches the field. Although water will remain without biological change while frozen, a sudden thaw will release large quantities of effluent within a very short time and may cause an undesirable runoff unless much more than the minimum acreage is available, or unless lagoons or basins are provided to collect the runoff.

Damage to the cover crop has been observed in northern regions when icecaps have remained for several days, particularly where the irrigated land was flat. The percentage of winter killing by icecaps is not so severe where the land is sloping. Some reseeding will be necessary each spring at sprinkler irrigation installations after winters of protracted freezing weather (11).

A hard rain will upset the best layouts designed for complete assimilation of surface water by the soil. Any resulting runoff will be so diluted by the rainwater that a minimum of pollution to public streams can be anticipated. However, since all waste water from poultry slaughtering may carry some pollutionary elements, protracted runoff cannot be permitted.

COST ESTIMATES FOR SPRINKLER SYSTEMS

To show the component parts of a sprinkler system and methods of computing investment and operating costs, several hypothetical plants have been set up. In these examples, it is assumed that each plant will operate 40 hours per week. Birds will be killed as they are received, and thus most of the problems of manure in sewage disposal will be eliminated. Blood will be collected at the bleeding tunnel or at some other point from which it can be removed for disposal through a rendering plant. Solid material, such as entrails, head, feet, feathers, and other nonedible parts, will be removed to the offal room for disposition to renderers or other outlets (4). About 1-2/3 gallons of water will be used per pound, live weight, of poultry slaughtered (5 gallons per chicken or 30 gallons per turkey).

Cost information is presented in table 1 for four sizes of plants.

Table 1.--Poultry slaughtered and waste water discharged in hypothetical poultry slaughtering plants, by size of plant

Size of plant	Poultry slaughtered per week (live weight)	Waste water discharged	
		Per week	Per hour
	Thousand pounds	Thousand gallons	Gallons
Small	18	30	750
Medium	180	300	7,500
Large	360	600	15,000
Extra large	1,000	1,660	41,500

Table 2 summarizes the engineering data developed for these hypothetical plants. Small plants need only one sprinkler head. It might even be desirable to use a flexible hose and to move the sprinkler head from place to place. For a medium-sized plant disposing of 125 gallons per minute, a similar system might be used. Two large sprinklers used at the end of flexible hoses should be satisfactory with 1/2-inch nozzles and a 10-horsepower motor. The same job might be done with ten 1/4-inch nozzles and aluminum pipeline. In this case, a 7-1/2 horsepower motor would be sufficient because of the reduced pressure requirements.

These data are merely estimates presented to illustrate typical engineering problems. Each installation must be designed to meet the specific situation. The engineering data developed for specific cases may be quite different from that presented in the tables given here. In general, however, the component parts will be comparable.

Capital Costs

The following costs are based on information received from equipment companies in 1957. The items included are those which might be required under ideal circumstances without allowance for irregularly shaped irrigation field, obstructions, or other factors which might add to investment costs. For individual systems, however, actual costs may vary considerably, particularly in costs of labor and local materials. For example, the reservoir, one of the major costs, may be built in some localities much cheaper than in others.

In a similar way, costs of screening equipment may vary considerably, depending upon the need for screening and the equipment already on hand.

Table 2.--Summary of engineering data for irrigation systems for poultry processing plants, by size of plant and size of nozzle 1/

Item	Small plant	Medium-sized plant		Large plant		Extra large plant
	1/4-inch nozzle	1/4-inch nozzle	1/2-inch nozzle	1/4-inch nozzle	1/2-inch nozzle	1/2-inch nozzle
Poultry handled per week.........1,000 lb..	18	180	180	360	360	1,000
Water used:						
Per week.....................1,000 gal..	30	300	300	600	600	1,660
Per hour.........................gal..	750	7,500	7,500	15,000	15,000	42,000
Per minute.......................gal..	12.5	125	125	250	250	700
Rate of application...............in./hr..	.5	.5	.5	.5	.5	.5
Depth of irrigation....................in..	4	4	4	4	4	4
Time per setting......................hr..	8	8	8	8	8	8
Area required........................acre..	1	3	3	5.5	5.5	15
Sprinkler discharge.............gal./min..	12.5	12.5	62.5	12.5	62.5	62.5
Pressure at sprinkler...........lb./sq.in..	45	45	70	45	70	70
Sprinklers............................No..	1	10	2	20	4	12
Laterals:						
Spacing..............................ft..	--	40	100	40	100	100
Length...............................ft..	--	360	100	760	300	1,200
Diameter.............................in..	--	2	2	3	2&3	4
Main line:						
Spacing..............................ft..	--	60	120	60	120	100
Length...............................ft..	300	300	600	300	600	1,200
Diameter.............................in..	2	4	4	5	5	7
Reservoir, 1-hour capacity...........gal..	750	7,500	7,500	15,000	15,000	42,000
Capacity of pump................gal./min..	12.5	125	125	250	250	700
Power................................hp..	1	7.5	10	15	20	60

1/ For illustrative purposes only. In actual practice, excess capacity would be provided to accommodate peak loadings, and standby facilities would probably be needed.

Throughout the discussion of costs it has been assumed that the reservoir and disposal field would be adjacent to the slaughtering plant. If this is not the case, additional pipe will be necessary to convey the water to the field reservoir, and an additional pump may be needed to move the effluent to the field. Costs may be reduced if the land to be irrigated is at a lower level than the processing plant so that gravity can be utilized. The costs which follow apply specifically to systems designed for minimum acreages. For costs which apply to general farm irrigation, see Agriculture Handbook 107 (8).

The cost of pipe may be estimated by using the following approximations:

Diameter of pipe (inches)	Cost per linear foot
2	$0.50
3	.70
4	.90
5	1.20
6	1.60
7	2.00

The estimated capital investment required for the various capacities described in tables 1 and 2 are as follows:

For plants slaughtering 18,000 pounds of poultry per week and using 1/4-inch sprinkler nozzles

Suction line assembly--3 inches in diameter	$ 55
Pump and motor--12.5 gallons per minute, 50 pounds per square inch, 1 horsepower	300
Discharge line assembly--2 inches in diameter	70
Main line--2 inches in diameter, 300 feet in length, @ 50 cents per foot	150
Lateral line	None
Sprinklers--1 @ $10	10
Reservoir--750 gallons capacity, 3 x 6 x 6 feet	200
Screen--basket type	50
Estimated total investment	$835

For plants slaughtering 180,000 pounds of poultry per week and using 1/4-inch sprinkler nozzles

Suction line assembly--4 inches in diameter	$ 60
Pump and motor--125 gallons per minute, 55 pounds per square inch, 7.5 horsepower	420
Discharge line assembly--4 inches in diameter	80
Main line--4 inches in diameter, 300 feet in length, @ $1.10 per foot	330
Lateral line--2 inches in diameter, 360 feet in length, @ 50 cents per foot	180

For plants slaughtering 180,000 pounds of poultry per week and using 1/4-inch sprinkler nozzles--continued

Sprinklers--10 @ $10 each	$ 100
Reservoir--7,500 gallons capacity, 6 x 13 x 13 feet	1,000
Screen, vibrating	1,000
Estimated total investment	$3,170

For plants slaughtering 180,000 pounds of poultry per week and using 1/2-inch sprinkler nozzles

Suction line assembly--4 inches in diameter	$ 60
Pump and motor--125 gallons per minute, 80 pounds per square inch, 10 horsepower	500
Discharge line assembly--4 inches in diameter	80
Main line--4 inches in diameter, 600 feet in length, @ $1.10 per foot	660
Lateral line--2 inches in diameter, 100 feet in length, @ 50 cents per foot	50
Sprinklers--2 @ $50 each	100
Reservoir--7,500 gallons capacity, 6 x 13 x 13 feet	1,000
Screen, vibrating	1,000
Estimated total investment	$3,450

For plants slaughtering 360,000 pounds of poultry per week and using 1/4-inch sprinkler nozzles

Suction line assembly--5 inches in diameter	$ 75
Pump and motor--250 gallons per minute, 56 pounds per square inch, 15 horsepower	640
Discharge line assembly--5 inches in diameter	110
Main line--5 inches in diameter, 300 feet in length, @ $1.40 per foot	420
Lateral line--3 inches in diameter, 760 feet in length, @ 75 cents per foot	570
Sprinklers--20 @ $10 each	200
Reservoir--15,000 gallons capacity, 8 x 16 x 16 feet	1,500
Screen, vibrating	2,500
Estimated total investment	$6,015

For plants slaughtering 360,000 pounds of poultry per week and using 1/2-inch sprinkler nozzles

Suction line assembly--5 inches in diameter	$ 75
Pump and motor--250 gallons per minute, 87 pounds per square inch, 20 horsepower	800
Discharge line assembly--5 inches in diameter	110
Main line--5 inches in diameter, 600 feet in length, @ $1.40 per foot	840

For plants slaughtering 360,000 pounds of poultry per week and using 1/2-inch sprinkler nozzles--continued

Lateral line--2 inches in diameter, 200 feet in length, @ 50 cents per foot, and 3 inches in diameter, 100 feet in length, @ 75 cents per foot	$ 175
Sprinklers--4 @ $50 each	200
Reservoir--15,000 gallons capacity, 8 x 16 x 16 feet	1,500
Screen, vibrating	2,500
Estimated total investment	$6,200

For plants slaughtering 1,000,000 pounds of poultry per week and using 1/2-inch sprinkler nozzles

Suction line assembly--7 inches in diameter	$ 150
Pump and motor--700 gallons per minute, 100 pounds per square inch, 60 horsepower	2,000
Discharge line assembly--7 inches in diameter	150
Main line--7 inches in diameter, 1,200 feet in length, @ $2 per foot	2,400
Lateral line--4 inches in diameter, 1,200 feet in length, @ $1 per foot	1,200
Sprinklers--12 @ $50 each	600
Reservoir--42,000 gallons capacity, 8 x 27 x 27 feet	3,000
Screen, vibrating	5,000
Estimated total investment	$14,500

Annual fixed costs for this equipment will equal the cost of each item divided by its estimated life, plus interest on the average investment per year. For most processors, depreciation can be computed on a declining-balance method or some other method that would permit more rapid depreciation than the straight-line method. A processor can group the items of equipment and give them the same expected life, 10 years, for example. In this case, a uniform depreciation rate of 10 percent of the unrecovered cost can be used. Suggested depreciation periods for selected items are:

Item	Depreciation period Years
Pump	15
Power:	
Diesel	15
LP-Gas	12
Gasoline, tractor fuel, etc	9
Air-cooled engine, gasoline	4
Electric motors	25
Open farm ditches (permanent)	20
Concrete structures	20

Item	Depreciation period
	Years
Concrete pipe systems..................	20
Wood flumes............................	8
Pipe:	
Surface gated........................	10
Waterworks class.....................	40
For use with aluminum sprinkler......	15
Steel, coated, underground...........	20
Steel, coated, surface use only......	10
Steel, galvanized, surface only......	15
Wood, underground....................	20
Sprinkler heads........................	8
Screens 1/.............................	5

1/ Estimated from opinions of equipment manufacturers, including obsolescence factor.

The depreciation period given above were compiled from a study of irrigation systems in the Southwest where supplementary irrigation has been used for many years. They are based on an average usage of 1,500 to 2,000 hours per year (5).

Depreciation and interest computed on a declining-balance method are shown in table 3.

Table 3.--Initial charges for depreciation and interest on spray irrigation equipment for plants of various size

Pounds of poultry slaughtered per week	Size of nozzle	Investment	Deduction	Interest	Total charge, first year
	Inch	Dollars	Dollars	Dollars	Dollars
18,000	1/4	835	110	50	160
180,000	1/4	3,170	421	190	611
180,000	1/2	3,450	459	207	666
360,000	1/4	6,015	800	361	1,161
360,000	1/2	6,200	825	372	1,197
1,000,000	1/2	14,500	1,928	860	2,788

Operating Costs

Operating costs, including power, maintenance, and labor, are costs which are fully deductible, and in some instances the businessman prefers to substitute operating costs for fixed costs wherever it is possible. For example,

he may decide that a portable irrigation system is preferable to a permanent type since the direct costs of labor can replace, to some extent, the larger investment required for the underground pipe installation. Capital costs can be recovered only over a long period of years. A discussion of these operating costs follows.

Labor

Labor is required to keep the disposal plant operating, move the nozzles from one field to another, and to maintain the system. When the pumping cycle is controlled by floats in the reservoir and when the irrigation field is in clear view of the plant, only occasional visits for inspection are required during a day's operation. If the irrigation field is not conveniently located and if control is manual rather than automatic, more labor is required for inspection and maintenance. In addition to the daily inspection service, labor is required to clean out the desilting and grease traps and to move and reconnect portable pipes. Estimates of the man-hours required are given in table 4.

Table 4.--Labor requirements for spray irrigation systems in poultry processing plants by size of plant and size of nozzle

Operation	Labor required per day in--					
	Small plants	Medium-sized plants		Large plants		Extra large plants
	1/4-in. nozzle	1/4-in. nozzle	1/2-in. nozzle	1/4-in. nozzle	1/2-in. nozzle	1/2-in. nozzle
	Hours	Hours	Hours	Hours	Hours	Hours
Visual inspection and adjustments during operation	0.1	0.9	0.1	1.5	0.2	1.5
Moving to new area	.1	.5	.3	.7	.5	1.0
Cleaning traps	1/	.1	.1	.1	.1	.2
Total	.2	1.5	.5	2.3	.8	2.7

1/ Less than 0.1 hour.

Labor will probably be performed by regular plant personnel, but skilled maintenance men must be available for the more complicated adjustments in the controls and the equipment.

Table 5.--Power required to pump different quantities of water against heads of 10 to 240 feet with pumping plant of 50-percent efficiency

Discharge (Gals./min.)	Power required for total head of--																
	10 feet	20 feet	30 feet	40 feet	50 feet	60 feet	70 feet	80 feet	90 feet	100 feet	120 feet	140 feet	160 feet	180 feet	200 feet	220 feet	240 feet
	Horse-power	Horse-power	Horse-power	Horse-power	Horse-power	Horse-power	Horse-power	Horse-power	Horse-power	Horse-power	Horse-power	Horse-power	Horse-power	Horse-power	Horse-power	Horse-power	Horse-power
25	1/8	1/4	1/3	1/2	2/3	3/4	1	1	1	1	2	2	2	2	3	3	3
50	1/4	1/2	3/4	1	1	2	2	2	2	3	3	4	4	5	5	6	6
100	1/2	1	2	2	3	3	4	4	5	5	6	7	8	9	10	11	12
150	3/4	2	2	3	4	5	5	6	7	8	9	11	12	14	15	17	18
200	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	22	24
250	1	3	4	5	6	8	9	10	11	13	15	18	20	23	25	28	30
300	2	3	5	6	7	9	11	12	14	15	18	21	24	27	30	33	36
350	2	4	5	7	9	11	12	14	16	18	21	25	28	32	35	39	42
400	2	4	6	8	10	12	14	16	18	20	24	28	32	36	40	44	48
450	2	5	7	9	11	14	16	18	20	23	27	32	36	41	45	50	54
500	2	5	8	10	13	15	18	20	23	25	30	35	40	45	50	55	60
600	3	6	9	12	15	18	21	24	27	30	36	42	48	55	61	67	73
700	4	7	11	14	18	21	25	28	32	35	42	50	57	64	71	78	85
800	4	8	12	16	20	24	28	32	36	40	48	57	65	73	81	89	97
900	5	9	14	18	23	27	32	36	41	45	55	64	73	82	91	100	109
1,000	5	10	15	20	25	30	35	40	45	51	60	71	80	91	101	111	121
1,250	6	13	19	25	32	38	44	50	57	63	76	88	101	114	126	139	151
1,500	8	15	23	30	38	45	53	60	68	76	90	106	121	136	151	166	181

Adapted from U. S. Dept. Agr. Farmers' Bul. 1857, Small Irrigation Pumping Plants (9).

Power Costs

Power costs can be estimated from tables which have been prepared by irrigation engineers. The first step is to estimate the power required per unit of time. This can be approximated from table 5.

After the horsepower requirements have been estimated, operating costs can be approximated by multiplying the average rate per kilowatt-hour (for electric motors) by the product of the horsepower required and 0.746. (With a rate of 2 cents per kilowatt hour and a 20 horsepower requirement, hourly costs would be 2 cents x 20 x .746 or 29.84 cents.)

For internal combustion engines, costs per horsepower will depend upon the costs of local fuels. The equipment engineer can prepare suitable estimates.

Maintenance

The cost of maintaining sprinkler systems is generally very small. It involves replacement of parts, such as sprinkler heads, gaskets, and connectors for portable pipes, screens, and other small parts as they wear out. Electrical repairs to the pump motor and occasional overhauling of the pump represent the largest expense in maintenance.

The total costs, which include depreciation, interest on investment, power, and labor per year, for spray irrigation in the foregoing examples are shown in table 6.

Table 6.--Fixed and operating costs of irrigation systems

Pounds of poultry slaughtered per week, per plant	Size of nozzle	Investment	Annual costs			
			Depreciation and interest on investment	Power	Labor @ $1 per hour	Total 1/
	Inch	Dollars	Dollars	Dollars	Dollars	Dollars
18,000.......	1/4	835	160	21	400	581
180,000.......	1/4	3,170	611	231	3,000	3,842
180,000.......	1/2	3,450	666	335	1,000	2,001
360,000.......	1/4	6,015	1,161	465	4,600	6,226
360,000.......	1/2	6,200	1,197	716	1,600	3,513
1,000,000.......	1/2	14,500	2,788	2,297	5,400	10,485

1/ These costs do not include land costs. The latter will vary by locality and cannot be estimated without knowledge of local conditions. It is believed that 5 acres should be available for each 18,000 pounds of weekly slaughter and more land would be advantageous.

SUMMARY OF SUGGESTIONS AND RECOMMENDATIONS

A. General restrictions placed on irrigation with industrial wastes

1. Primary treatment is needed to remove settable solids and offensive substances from the wastes.

2. Land should be suitable, as shown by percolation rate and slope, and it should be isolated so as to protect the public.

3. A nuisance must not be created.

4. Contamination of public waters and runoff in streams should be avoided.

5. Land in low-growing vegetables or root crops for human consumption must not receive industrial wastes.

6. Blood, feathers, and small pieces of solid material should be removed.

7. Wastes must not be permitted to pool, or favorable spots for breeding of insects be created.

B. Practices now expected of sanitary poultry slaughtering and dressing plants

1. Plants should be kept clean and sanitary so that no odor or public health nuisance is created.

2. Federal Food and Drug regulations govern.

3. Feathers, discarded members, and entrails should be collected in separate drums for disposition to rendering plants, for burning, or for drying, grinding, and application as fertilizer. Liquid wastes should be: (a) screened, (b) skimmed or settled, or (c) in other ways treated to reduce BOD and remove suspended solids to conform to applicable requirements.

4. Some States require prior approval before methods of disposal of food plant wastes are changed.

C. Suggestions to make poultry plant liquid waste disposal through land irrigation feasible and practical for both the plant operator and public health

1. The waste should be of such character that it will not clog pores in the soil or create odors or public nuisance in the area.

2. Possibilities of using ridge and furrow irrigation in northern climates should be investigated.

3. Capacity of a given soil should be carefully estimated.

4. Solids should be removed to prevent fly breeding.

5. Operators of irrigation systems should be given instructions on applicable measures of sanitation in sewage handling.

6. The field should be properly located in relation to occupied buildings, geological structure, subsoil formations, and winter conditions.

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APPENDIX

EXAMPLES OF RATES OF APPLICATION OF WASTE WATER THROUGH IRRIGATION

(a) 2,500 to 5,000 gallons per acre per day (6).

(b) 360,000 gallons per 10-hour day on 40 acres (average 0.033 inch per day) (1).

(c) 20,000 gallons per day maximum, average 16,000 gallons per day, on 4.7 acres but extending to 8 acres because of sharp fall of land which causes runoff. 5/

(d) 3 to 4 inches at rate of 0.4 to 0.6 inches per hour with 6-day rest between applications throughout growing season. In one State, the average is 1/2 inch to 3/4 inch per acre per day, which includes allowances for rest periods. 6/

(e) At Madison, Wis., 40 inches or more of packinghouse sewage effluent can be applied to a crop of Reed canarygrass during the growing season, weather conditions being normal (silt loam soil) (2).

5/ Unpublished letter from Rex A Bullock, Kraft Foods Company, Lafayette, Tenn., May 22, 1957.

6/ Canham, Robert A. Current Trends in Handling Canning Wastes. Paper presented at the 5th Annual Water Symposium on Water Pollution, at Louisiana State University, Baton Rouge, La., February 1956.

(f) Typical installations (6)

Plant location	Waste per day	Land irrigated	Rate of application per acre per day
	Gallons	Acres	Gallons
Tennessee	12,600	2	6,300
New Jersey	75,000	45	1,670
New Jersey	75,000	30	2,500
Ontario, Canada	8,000	3	2,700
Indiana	10,000	6	1,670
Wisconsin	6,000	2.5	2,400
Kentucky	26,000	6	4,200

(g) Milk processors in Wisconsin: 7/

Product	Maximum waste per day	Land irrigated	Soil type	Average waste per acre per day
	Gallons	Acres		Gallons
Cheese	800	1.0	Silt loam	800
Cheese	3,000	3.0	Silty clay	1,000
Cheese	6,000	8.0	Silt loam	750
Cheese	2,000	2.0		1,000
Butter	51,600	15.0	Clay hardpan	3,440
Cheese	42,670	26.0	Clay loam	1,641
Cheese	5,900	2.5	Silty	2,360
Cheese	3,000	2.0	Silt loam	1,500
Cheese	8,750	9.0	Heavy clay	972
Cheese	200	.5	Homemade	400
Cheese	3,600	.8	Miami loam	4,500
Butter and cheese	14,000	5.5	Silt soil	2,545
Cheese	9,700	1.0	Sand	9,700
Cheese	3,000	2.0	Sandy soil	1,500
Cheese	2,000	.5	Silt loam	4,000
Cheese	4,300	2.5	Silt loam	1,720

(h) Dairy disposing of 75,000 gallons per day and including wastes from 135 employees and 130 cows. Entire farm available but only 45 acres of hay land used (10).

7/ See footnote 4, p. 7.

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